

(12) **United States Patent**
Grzesik et al.

(10) **Patent No.:** **US 10,029,936 B2**
(45) **Date of Patent:** **Jul. 24, 2018**

(54) **APPARATUS FOR FORMING GLASS WITH EDGE DIRECTORS AND METHODS**

(71) Applicant: **Corning Incorporated**, Corning, NY (US)
(72) Inventors: **Paul Richard Grzesik**, Canandaigua, NY (US); **Ahdi El Kahlout**, Lexington, KY (US); **Nicolas LeBlond**, Painted Post, NY (US); **Gaozhu Peng**, Horseheads, NY (US); **Kim E Womer**, Beaver Dams, NY (US)

(73) Assignee: **Corning Incorporated**, Corning, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 406 days.

(21) Appl. No.: **14/310,665**

(22) Filed: **Jun. 20, 2014**

(65) **Prior Publication Data**

US 2014/0298861 A1 Oct. 9, 2014

Related U.S. Application Data

(62) Division of application No. 13/482,336, filed on May 29, 2012, now Pat. No. 8,794,034.

(51) **Int. Cl.**
C03B 17/06 (2006.01)

(52) **U.S. Cl.**
CPC **C03B 17/064** (2013.01)

(58) **Field of Classification Search**
CPC C03B 17/06; C03B 17/064
USPC 65/53, 90, 91, 98, 195
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,190,296 A *	2/1940	Richardson	65/325
2,234,986 A *	3/1941	Slayter et al.	65/447
3,451,798 A *	6/1969	Simon	65/199
3,537,834 A *	11/1970	Simon	65/199
3,672,880 A *	6/1972	Darling	420/467
4,473,387 A	9/1984	Lecron et al.	
5,017,205 A	5/1991	Shioura et al.	
7,409,839 B2 *	8/2008	Boratav et al.	65/199
7,685,841 B2 *	3/2010	Boratav et al.	65/93

(Continued)

FOREIGN PATENT DOCUMENTS

KR	10-2007-0108252	11/2007	C03B 17/06
KR	10-2009-0016564	2/2009	C03B 17/06

(Continued)

OTHER PUBLICATIONS

L. Cao, T. P. Price, M. Weiss and D. Gao, *Langmuir*, 2008, 24, 1640-1643.*

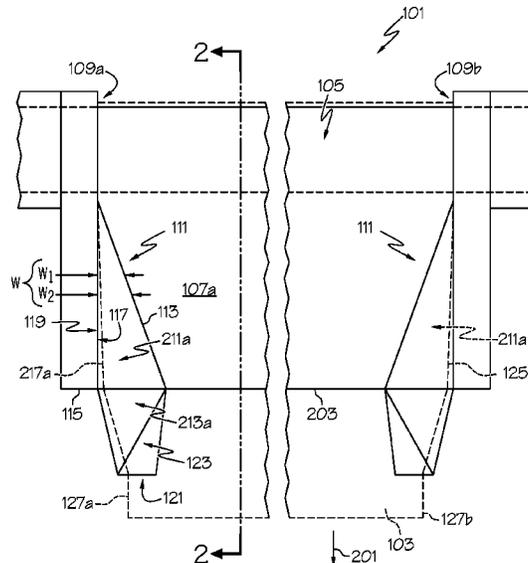
(Continued)

Primary Examiner — Jason L Lazorcik

(57) **ABSTRACT**

An apparatus for downwardly drawing glass ribbon comprises edge directors, wherein an outer portion defining a first pair of surfaces and a second pair of surfaces. In one example, the first and second pair of surfaces of each edge director includes a glass wettability with a static contact angle within a range of from about 30° to about 60°. In another example, the outer portion comprises a platinum alloy including from about 0.05 weight % tin to about 5 weight % tin. Methods for forming glass include the step of providing the edge director with a desired glass wettability and/or a desired platinum alloy.

19 Claims, 3 Drawing Sheets



(56)

References Cited

U.S. PATENT DOCUMENTS

2005/0183455 A1 8/2005 Pitbladdo
2010/0083704 A1* 4/2010 Grzesik et al. 65/51
2011/0209502 A1 9/2011 El Kahlout et al.

FOREIGN PATENT DOCUMENTS

KR 10-2011-0130438 12/2011 C03B 18/06
WO 2011136109 A1 11/2011

OTHER PUBLICATIONS

Copley, G.J., Rivers, A.D., Smith, R., "Contact angle measurements of E-Glass with platinum group metals", journal of Materials Science 10 (1975) 1285-1290.*
Ning, Y. Wang, Y., and Yuan, Q., "a bond parameter approach to wettability of molten glass on Pt alloy", Acta Metallurgical Sinica , vol. 17, No. 4, Aug. 1981, p. 461-466.*
English Translation of CN201380034758.0 First Office Action dated March 23, 2016, China Office Patent.
International Search Report and Written Opinion of the International Searching Authority; PCT/US2013/043093; dated Aug. 19, 2013.
English Translation of Taiwan Search Report TW102118686 dated Sep. 1, 2016, Taiwan Patent Office.
Materials Science of Noble Metal, Edited by Li Dingxin, p. 443, South China University of Industry Press, Nov. 1991.

* cited by examiner

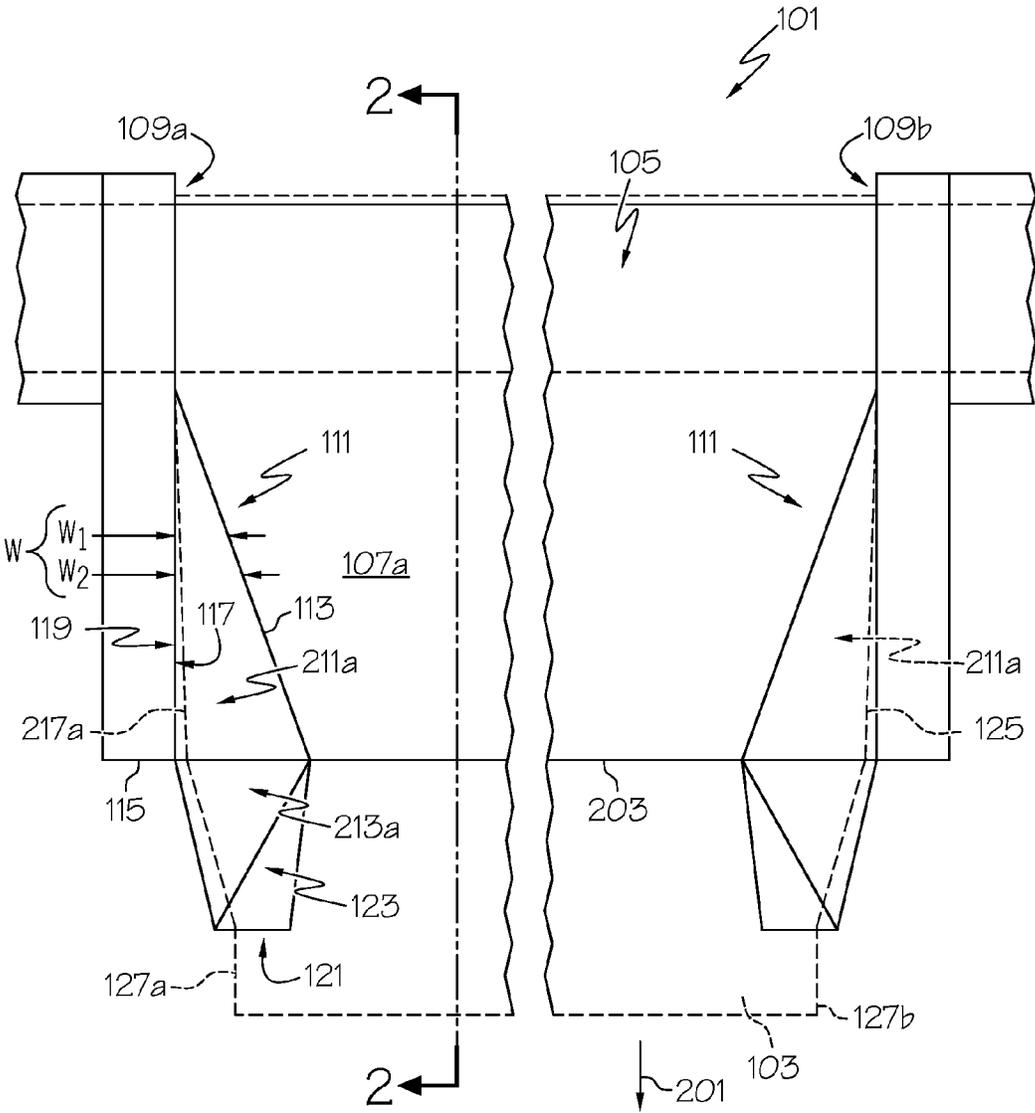


FIG. 1

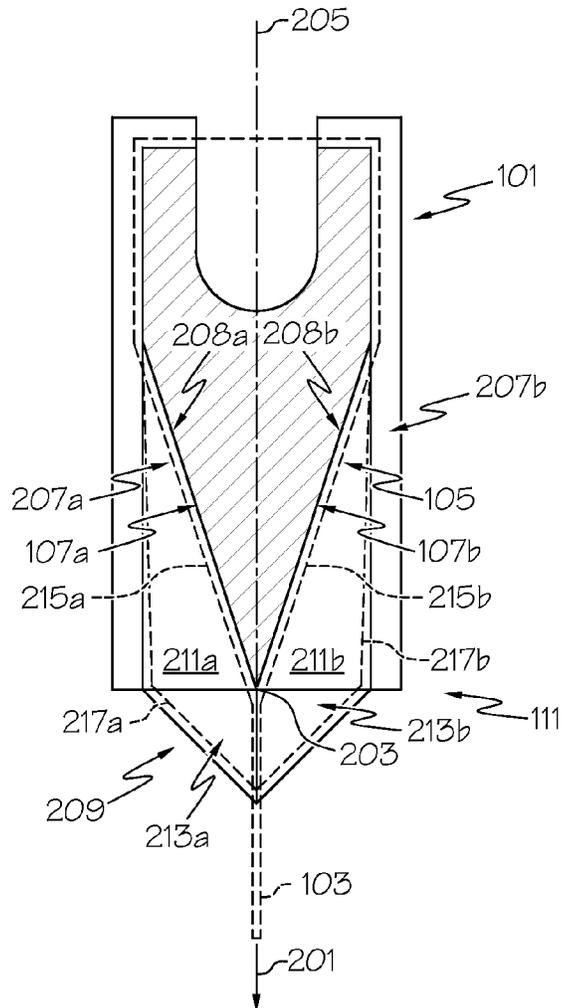


FIG. 2

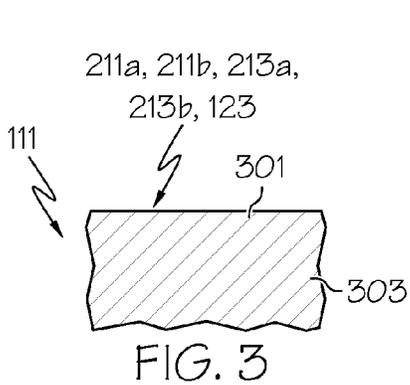


FIG. 3

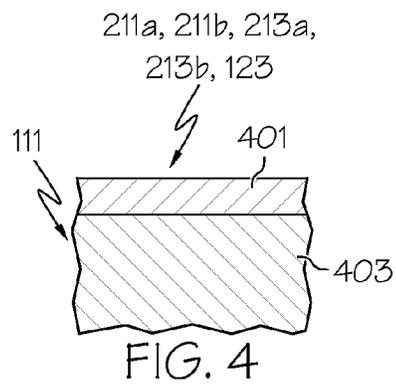


FIG. 4

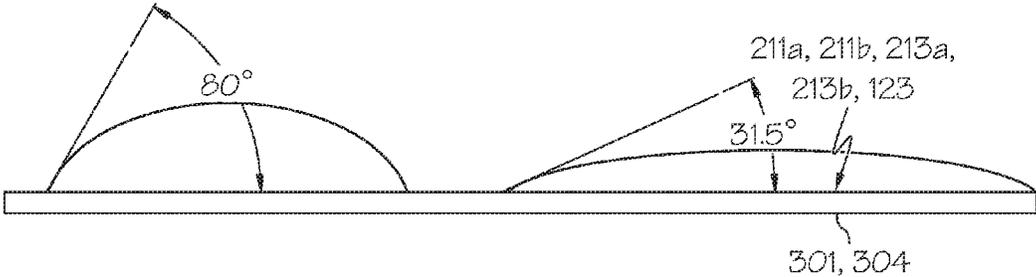


FIG. 5

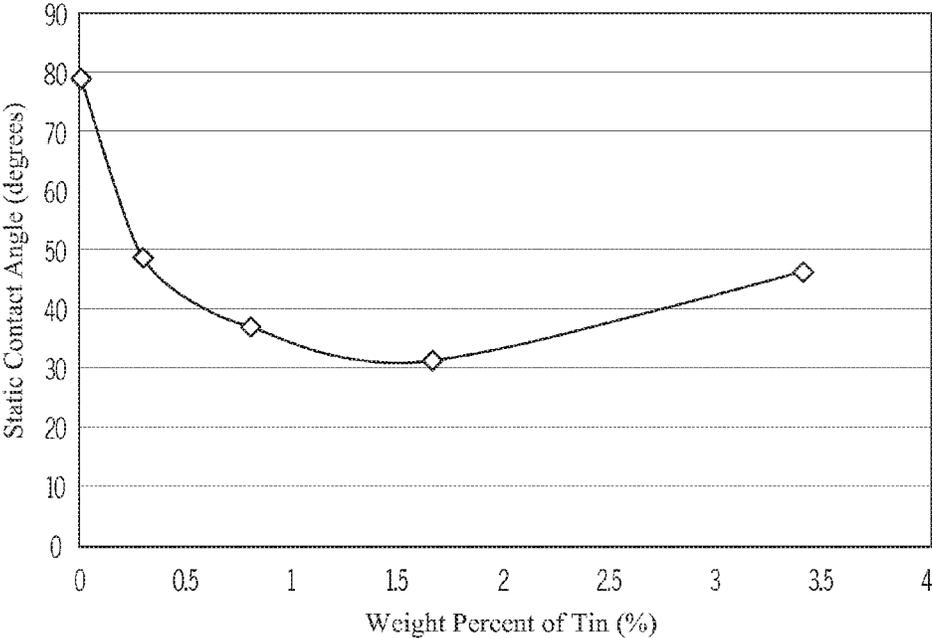


FIG. 6

APPARATUS FOR FORMING GLASS WITH EDGE DIRECTORS AND METHODS

CROSS-REFERENCE TO RELATED APPLICATIONS

This is a divisional of U.S. patent application Ser. No. 13/482,336 filed on May 29, 2012, the content of which is relied upon and incorporated herein by reference in its entirety, and the benefit of priority under 35 U.S.C. §120 is hereby claimed.

FIELD OF THE INVENTION

The present invention relates generally to apparatus and methods for forming glass, and more particularly, to apparatus and methods for forming glass with edge directors.

BACKGROUND OF THE INVENTION

It is known to manufacture glass ribbon by downwardly flowing molten glass over a forming wedge. Edge directors are frequently provided at opposed ends of the forming wedge to help maintain sheet width and minimize edge bead. There is a continued need for edge directors to control the sheet edges, for example, with high end glass compositions.

BRIEF SUMMARY OF THE INVENTION

The following presents a simplified summary of the invention in order to provide a basic understanding of some example aspects of the invention. This summary is not an extensive overview of the invention. Moreover, this summary is not intended to identify critical elements of the invention nor delineate the scope of the invention. The sole purpose of the summary is to present some concepts of the invention in simplified form as a prelude to the more detailed description that is presented later.

In accordance with one aspect of the present disclosure, an apparatus for downwardly drawing glass ribbon comprises a forming wedge including a pair of inclined surface portions extending between opposed ends of the forming wedge and converging along a downstream direction to form a root. A draw plane extends through the root. The apparatus also includes an edge director positioned at each of the opposed ends. Each edge director includes an outer portion defining a first pair of surfaces and a second pair of surfaces. The first pair of surfaces each extend from a corresponding one of the pair of inclined surface portions. The second pair of surfaces extend from the first pair of surfaces and converge toward the draw plane. The first and second pair of surfaces of each edge director includes a glass wettability with a static contact angle within a range of from about 30° to about 60°, such as from about 30° to about 50°.

In another example of the aspect, at least the outer portion of each edge director comprises a platinum alloy.

In yet another example of the aspect, the platinum alloy includes a metal selected from the group consisting of tin, copper and silver.

In still another example of the aspect, the platinum alloy includes tin. For instance, the platinum-tin alloy can include less than about 5 weight % tin, such as from about 0.05 weight % tin to about 3.5 weight % tin, such as from about 0.5 weight % tin to about 2.5 weight % tin.

In accordance with another aspect of the disclosure, an apparatus for downwardly drawing glass ribbon comprises a forming wedge including a pair of inclined surface portions

extending between opposed ends of the forming wedge and converging along a downstream direction to form a root. A draw plane extends through the root. The apparatus further includes an edge director positioned at each of the opposed ends. Each edge director includes an outer portion defining a first pair of surfaces and a second pair of surfaces. The first pair of surfaces each extend from a corresponding one of the pair of inclined surface portions and the second pair of surfaces extend from the first pair of surfaces and converge toward the draw plane, wherein the outer portion comprises a platinum alloy including from about 0.05 weight % tin to about 5 weight % tin.

In accordance with one example of the aspect, the platinum alloy includes from about 0.05 weight % tin to about 3.5 weight % tin, such as from about 0.5 weight % tin to about 2.5 weight % tin.

In another example of the aspect, the first and second pair of surfaces of each edge director includes a glass wettability with a static contact angle within a range of from about 30° to about 60°, such as from about 30° to about 50°.

In accordance with yet another aspect of the disclosure, a method for forming glass comprises the step of providing a forming wedge including a pair of inclined surface portions extending between opposed ends of the forming wedge and converging along a downstream direction to form a root, wherein a draw plane extends through the root. The method also includes the step of providing an edge director positioned at each of the opposed ends. Each edge director includes an outer portion defining a first pair of surfaces and a second pair of surfaces. The first pair of surfaces each extend from a corresponding one of the pair of inclined surface portions and the second pair of surfaces extend from the first pair of surfaces and converge toward the draw plane. The first and second pair of surfaces of each edge director includes a glass wettability with a static contact angle within a range of from about 30° to about 60°, such as from about 30° to about 50°. The method also includes the step of flowing a molten glass sheet over each of the pair of inclined surface portions of the forming wedge. The method further includes the step of flowing a first pair of lateral edges of the molten glass sheets over corresponding first surfaces of the first edge director and flowing a second pair of lateral edges of the molten glass sheets over corresponding first surfaces of the second edge director, wherein the thickness of each of the first and second pair of lateral edges is decreased. The method also includes the step of flowing the first pair of lateral edges over corresponding second surfaces of the first edge director and flowing the second pair of lateral edges of the molten glass sheets over corresponding second surfaces of the second edge director, wherein the first and second pair of lateral edges each converge together toward the draw plane. The method also includes the step of drawing the first pair of lateral edges off the first edge director and drawing the second pair of lateral edges off the second edge director, wherein the first pair of lateral edges fuse together to form a first fused edge of a glass ribbon and the second pair of lateral edges fuse together to form a second fused edge of the glass ribbon.

In accordance with another example of the aspect, the outer portion comprises a platinum alloy including from about 0.05 weight % tin to about 5 weight % tin, such as from about 0.05 weight % tin to about 3.5 weight % tin.

In accordance with yet another aspect of the disclosure, a method for forming glass comprises the step of providing a forming wedge including a pair of inclined surface portions extending between opposed ends of the forming wedge and converging along a downstream direction to form a root,

wherein a draw plane extends through the root. The method also includes the step of providing an edge director positioned at each of the opposed ends. Each edge director includes an outer portion defining a first pair of surfaces and a second pair of surfaces. The first pair of surfaces each extend from a corresponding one of the pair of inclined surface portions and the second pair of surfaces extend from the first pair of surfaces and converge toward the draw plane. The outer portion comprises a platinum alloy including from about 0.05 weight % tin to about 5 weight % tin, such as from about 0.05 weight % tin to about 3.5 weight % tin, such as from about 0.5 weight % tin to about 2.5 weight % tin. The method also includes the step of flowing a molten glass sheet over each of the pair of inclined surface portions of the forming wedge. The method still further includes the step of flowing a first pair of lateral edges of the molten glass sheets over corresponding first surfaces of the first edge director and flowing a second pair of lateral edges of the molten glass sheets over corresponding first surfaces of the second edge director, wherein the thickness of each of the first and second pair of lateral edges is decreased. The method also includes the step of flowing the first pair of lateral edges over corresponding second surfaces of the first edge director and flowing the second pair of lateral edges of the molten glass sheets over corresponding second surfaces of the second edge director, wherein the first and second pair of lateral edges each converge together toward the draw plane. The method also includes the step of drawing the first pair of lateral edges off the first edge director and drawing the second pair of lateral edges off the second edge director, wherein the first pair of lateral edges fuse together to form a first fused edge of a glass ribbon and the second pair of lateral edges fuse together to form a second fused edge of the glass ribbon.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other aspects of the present invention will become apparent to those skilled in the art to which the present invention relates upon reading the following description with reference to the accompanying drawings, in which:

FIG. 1 a partial schematic side view of an apparatus for forming glass with edge directors incorporating example aspects of the present disclosure;

FIG. 2 is a sectional view of the apparatus along line 2-2 of FIG. 1;

FIG. 3 is a partial sectional view of a portion of the edge director in accordance with one example of the disclosure;

FIG. 4 is a partial sectional view of a portion of the edge director in accordance with another example of the disclosure;

FIG. 5 illustrates different static contact angles resulting from different sample compositions; and

FIG. 6 is a chart demonstrating different static contact angles resulting from different sample compositions.

DETAILED DESCRIPTION

Example embodiments that incorporate one or more aspects of the present invention are described and illustrated in the drawings. These illustrated examples are not intended to be a limitation on the present invention. For example, one or more aspects of the present invention can be utilized in other embodiments and even other types of devices. Moreover, certain terminology is used herein for convenience only and is not to be taken as a limitation on the present

invention. Still further, in the drawings, the same reference numerals are employed for designating the same elements.

Aspects of the present invention can be used with various apparatus for drawing glass ribbon. FIGS. 1 and 2 illustrate aspects of one example apparatus 101 for downwardly drawing a glass ribbon 103. The example apparatus 101 comprises a forming wedge 105 including a pair of inclined surface portions 107a, 107b extending between opposed ends 109a, 109b of the forming wedge 105. As shown in FIG. 2, the pair of inclined surface portions 107a, 107b converges along a downstream direction 201 to form a root 203. A draw plane 205 extends through the root 203 wherein the glass ribbon 103 may be drawn in the downstream direction 201 along the draw plane 205. As shown, the draw plane 205 can bisect the root 203 although the draw plane 205 may extend at other orientations with respect to the root 203.

As shown in FIG. 1, an edge director can be positioned at each of the opposed ends of the forming wedge. Indeed, a first edge director 111 can be positioned at a first end 109a and a second identical edge director 111 can be positioned at a second end 109b. Providing identical edge directors can be beneficial to provide a uniform glass sheet although the edge directors may have different configurations in further examples.

As shown in FIG. 2, the edge director 111 can include a pair of upper portions 207a, 207b that may be joined together by a lower portion 209. Joining the upper portions together can be beneficial to simplify assembly of the edge director 111 to the forming wedge 105. In further examples, the upper portions 207a, 207b may be provided separately. For example, the edge director 111 can be separate from one another and assembled independently to each of the pair of inclined surface portions 107a, 107b of the forming wedge 105. With certain configurations, providing upper portions that are not joined may simplify manufacturing of the edge directors.

The edge directors 111 can be mounted to the forming wedge 105 by engaging an inner surface portion 208a of the first upper portion 207a with the first inclined surface portion 107a of the forming wedge 105. Likewise, an inner surface portion 208b of the second upper portion 207b can be engaged with the second inclined surface portion 107b of the forming wedge 105. As shown in FIG. 1, each opposed end 109a, 109b can include a retaining block 115 designed to help laterally position the corresponding edge director 111 in place. For example, optional retaining blocks 115 can include a pair of planar surfaces 117 (only one shown in FIG. 1) that straddle the forming wedge 105. The planar surfaces 117 are designed to abut corresponding planar surfaces 119 (only one shown in FIG. 1) of the pair of upper portions 207a, 207b of the edge director 111. Once positioned, the edge directors 111 can be fastened in the position shown.

The pair of upper portions 207a, 207b of the edge director 111 can include a corresponding pair of first surfaces 211a, 211b. As shown in FIG. 2, the first pair of surfaces 211a, 211b can each extend from a corresponding one of the pair of inclined surface portions 107a, 107b. For example, the first surface 211a can extend from a first inclined surface portion 107a and the second surface 211b can extend from the second inclined surface portion 107b of the forming wedge 105. As shown, the first pair of surfaces 211a, 211b can be substantially planar although the surfaces can be substantially concave and/or include other surface characteristics in further examples. Moreover, as shown, the first

pair of surfaces **211a**, **211b** are identical to one another although the surfaces may have different configurations in further examples.

As shown in FIG. 1, each of the first pair of surfaces **211a**, **211b** can include a transverse width “W” that increases in the downstream direction **201**. For example, as shown, the first surfaces can have a first transverse width “W1” and a second downstream transverse width “W2” that is greater than the first transverse width “W1.” As shown, the transverse width “W” can increase in a substantially constant manner to define a linear edge **113** configured to follow the profile of the corresponding inclined surface portion of the forming wedge **105**. Although not shown, the transverse width of further embodiments herein may increase in non-linear fashion.

Referring again to FIG. 2, the edge director **111** can further include a second pair of surfaces **213a**, **213b** extending from the first pair of surfaces **211a**, **211b** and converging toward the draw plane **205** downstream from the root **203**. As shown, the second pair of surfaces **213a**, **213b** can be substantially planar although the surfaces can be substantially concave and/or include other surface characteristics in further examples. Moreover, as shown, the second pair of surfaces **213a**, **213b** can be substantially identical to one another although the surfaces may have different configurations in further examples.

The edge director **111** can still further include an optional downstream structure extending with respect to the second pair of surfaces **213a**, **213b** and downstream from the root **203**. As shown in FIG. 1, the downstream structure of the edge director **111** can comprise an optional blade **121** extending with respect to the second pair of surfaces **213a**, **213b**. The blade **121** can comprise a first surface **123** extending from the first surface **213a** of the second pair of surface and a second surface (not shown) extending from the second surface **213b** of the second pair of surfaces.

FIG. 3 is representative of a partial cross section of an outer portion **301** of the edge director **111** that defines the first pair of surfaces **211a**, **211b** and the second pair of surfaces **213a**, **213b**. Optionally, the outer portion **301** of the edge director **111** can also define the first surface **123** and/or the second surface of the blade **121** if provided. As shown in FIG. 3, the outer portion **301** can be of the same composition as an inner portion **303** of the edge director **111**. For example, the entire edge director **111** can be formed from a single composition material and/or may be provided as a single integral piece.

FIG. 4 is a representative partial cross section of another outer portion **401** of the edge director **111** that defines the first pair of surfaces **211a**, **211b** and the second pair of surfaces **213a**, **213b**. Optionally, the outer portion **401** of the edge director **111** can also define the first surface **123** and/or the second surface of the blade **121** if provided. As shown in FIG. 4, the outer portion **401** can be of a different composition than the inner portion **403**. For example, the outer portion **401** may comprise a layer of material that is disposed over an inner portion **403** of the edge director **111**. The outer portion **401** may be provided by vapor deposition to the inner portion **403** or other techniques.

In one example, an existing edge director may be retrofitted to include the outer portion **401**. For example, a platinum alloy may be provided as an outer portion **401** on an inner portion **403** comprising an existing platinum edge director. In such an example, a coating of tin, silver and/or copper can be applied onto a standard pure platinum edge

director affects the wetting of the glass surface with the molten glass. The coating could be applied using one of various methods, although electroplating may be particularly well suited to provide the metal coating. The coating could consist of pure tin, silver, copper and/or a mixture of these metals, or a mixture of one or more of these metals with platinum. For example, a platinum-tin coating may be applied to a pure platinum edge director in examples of the disclosure.

The first pair of surfaces **211a**, **211b** and the second pair of surfaces **213a**, **213b** defined by the outer portion **301**, **401** can include a glass wettability that is relatively high when compared to the surfaces of a conventional edge director. As used throughout the application, glass wettability can be defined as how easily a cylinder Eagle XG® glass spreads over a horizontal surface in accordance with the following testing procedure. The glass wettability, as used herein, can be measured by conducting an experiment where a 9 mm diameter×12 mm height glass cylinder of Eagle XG® glass is placed on a surface of a sample to be tested. Eagle XG® glass is available from Corning, Inc., and has a glass composition of Eagle XG® glass as available from Corning, Inc. on the filing date of this application. During the test, the sample with the glass cylinder is placed in a furnace that is fitted with a fused silica muffle. The furnace is heated at a rate of 10° C./min to 1200° C. measured at the same test location in air. The temperature is then held at 1200° C. for 20 hours. After holding the temperature for 20 hours, images of the glass drops are acquired and the static contact angle can then be measured at the interface of the glass drops and the surface of the sample. Exact values of the contact angles may change for different glass compositions. In some examples, features of the disclosure can be used with Alkaline Earth Boro-Aluminosilicate glasses (e.g., Eagle XG® glass) or other glass compositions.

The left side of FIG. 5 illustrates the glass wettability of a conventional surface of a conventional pure as-rolled platinum sample. As shown, the glass wettability is relatively low since the contact angle (i.e., about 80°) is relatively high. In contrast, the right side of FIG. 5 illustrates the glass wettability of a surface in accordance with aspects of the present disclosure including a platinum alloy that is likewise rolled with a similar surface roughness when compared to the surface roughness of the conventional sample on the left. As shown, the platinum alloy sample of FIG. 5 comprises a platinum alloy including 1.65 weight % tin (Sn) and the remaining weight of the sample comprising platinum (Pt). As shown, the surface of the present invention can include a relatively high wettability since the static contact angle is relatively low (i.e., about 31.5° on the right side of FIG. 5).

Glass wettability can be influenced by the surface roughness of the sample. It was observed, however, that the static contact angle of a surface from an as-rolled pure platinum surface was approximately the same as a 320 grit-roughened pure platinum surface having a surface roughness of about 8-10 microinches. However, the static contact angle of a sand-blasted pure platinum sample was significantly higher, indicating a reduced glass wettability. As such, aspects of the disclosure may optionally be used with surface roughnesses of less than 8-10 microinches.

As set forth above, a surface with relatively high glass wettability can be defined as those surfaces with relatively low contact angles after conducting the testing procedure above. Likewise, a surface with relatively low glass wettability can be defined as those surfaces with relatively high contact angles after conducting the testing procedure above.

In some examples of the present invention, the first and second pair of surfaces **211a**, **211b**, **213a**, **213b** can include a relatively high glass wettability with a static contact angle of less than about 60°, such as from about 30° to about 60°, such as from about 30° to about 50°, such as from about 30° to about 40°, such as from about 30° to about 35°.

Providing a relatively high glass wettability can be desired to enhance glass formation in accordance with aspects of the disclosure. Indeed, a relatively high glass wettability is believed to facilitate reduction of devitrification growth on the edge director, thereby, increasing the life of the edge director and improve short and long term thickness and fused edge bead quality of the glass ribbon.

Increasing the glass wettability can be achieved, for example, by providing an edge director from a platinum alloy rather than fabricating the edge director from pure platinum. Providing a platinum alloy can increase the strength of the edge director while also increasing the glass wettability. In one example, desirable glass wettability may be achieved wherein the platinum alloy comprises a metal selected from the group consisting of tin, copper and silver. For instance, the platinum alloy can include tin. Tin may be particularly beneficial in applications where the apparatus will be downwardly drawing glass including tin within the composition of the glass. As such, tin will remain in the glass and there will be a reduced tendency of tin otherwise being drawn out of the glass into the pure platinum. In a case where pure platinum is used for the edge director, the outer surface of the pure platinum edge director in contact with the molten glass including tin in the molten glass composition may form a platinum-tin alloy at the contact surface of the edge director but in reduced quantities less than 0.01 weight percent tin and in a quantity that does not result in increased glass wettability to the point where the contact angle would be reduced to a static contact angle of 60° or less.

It is also noted that providing a platinum tin alloy was observed to result in a liquidus temperature for Eagle XG® glass at the Pt—Sn interface (~98% Pt/2% Sn) that is comparable or lower than that of a Pt interface (100% Pt).

FIG. 6 is a chart demonstrating observed glass wettability with a platinum alloy including different weight percentages of tin (Sn) with the remaining weight comprising platinum (Pt). The vertical axis is the static contact angle in degrees and the horizontal axis is the weight percent of tin (Sn). As shown, with a pure as-rolled platinum (~100%/Pt/0% Sn), the static contact angle is approximately 80°. As shown, small amounts of tin (Sn) in the platinum alloy can significantly lower the static contact angle and thereby increase the glass wettability of the surface. For instance, as shown, a platinum-tin alloy of about 0.3 weight percent tin (~99.7% Pt/0.3% Sn) was observed to reduce the contact angle to 49°. As further illustrated, a platinum-tin alloy of about 0.8 weight percent tin (~99.2% Pt/0.8% Sn) was observed to further reduce the contact angle to 37°. As still further illustrated, a platinum-tin alloy of about 1.65 weight percent tin (~98.35%/Pt/1.65% Sn) was observed to further reduce the contact angle to 31.5°. However, it was also observed that a platinum alloy with higher percentages of tin (Sn) provided no further benefit in reduced contact angle, although the contact angle was still reduced when compared to a pure as-rolled platinum sample. For instance, a platinum alloy of about 3.4 weight percent tin (~96.6% Pt/3.4% Sn) was observed to increase the static contact angle to about 46.3°. Therefore, the increased amount of tin beyond a certain point was observed to decrease the glass wettability. The decrease in wettability may be due to inhomogeneity within the platinum-tin alloy. Based on the curve fitted to the

data shown in FIG. 6, maximum glass wettability may occur with a platinum-tin alloy of about 1.5 weight percent tin (Sn) (~98.5% Pt/1.5% Sn).

In some examples, at least the outer portion **301**, **401** of each edge director **111** comprises a platinum-tin alloy including tin in an amount that is less than about 5 weight % tin. For example, the platinum-tin alloy can include from about 0.05 weight % tin to about 3.5 weight % tin, such as about 0.07 weight % tin to about 3.5 weight % tin, such as about 0.1 weight % tin to about 3.5 weight % tin, such as about 0.3 weight % tin to about 3.5 weight % tin. In another example, the platinum-tin alloy can include from about 0.5 weight % tin to about 2.5 weight % tin, such as from about 1 weight % tin to about 2 weight % tin, such as about 1.25 weight % tin to about 1.75 weight % tin, such as about 1.5 weight % tin.

In further examples, at least the outer portion **301**, **401** of each edge director **111** may comprise a platinum alloy (e.g., including tin, copper and/or silver) in an amount such that the static contact angle is less than about 60°, such as from about 30° to about 60°, such as from about 30° to about 50°, such as from about 30° to about 40°, such as from about 30° to about 35°.

A method for forming glass will now be described with respect to an apparatus **101** including the example edge directors **111**. It will be appreciated that similar or identical method steps may be performed with further examples, for instance, as described throughout the application. Moreover, example methods of the present invention may omit and/or add additional steps. Unless noted, the steps can be performed simultaneously, sequentially or in different orders depending on the particular application.

As shown in FIGS. 1 and 2, methods of forming glass with the example apparatus **101** including the edge directors **111** as schematically illustrated. FIG. 2 illustrates example methods being performed with the first edge director **111** located at the first end **109a** of the forming wedge **105**. FIG. 2 is also representative of a cross section taken at the opposite direction illustrated in FIG. 1. Thus, FIG. 2 also represents example methods being performed with the second edge director **111** located at the second end **109b**.

The method can include the step of providing the forming wedge **105** including the pair of inclined surface portions **107a**, **107b** extending between the opposed ends **109a**, **109b** of the forming wedge **105** and converging along the downstream direction **201** to form the root **203**. As shown in FIG. 2, the draw plane **205** extends through the root **203**.

The method further includes the step of providing the edge director **111** positioned at each of the opposed ends **109a**, **109b**. As discussed previously with respect to FIGS. 3 and 4, each edge director **111** includes the outer portion **301**, **401** defining the first pair of surfaces **211a**, **211b** and the second pair of surfaces **213a**, **213b**. The first pair of surfaces **211a**, **211b** each extends from the corresponding one of the pair of inclined surface portions **107a**, **107b** of the forming wedge **105**. Moreover, the second pair of surfaces **213a**, **213b** extends from the first pair of surfaces **211a**, **211b** and converge toward the draw plane **205**.

In one example, the first and second pair of surfaces **211a**, **211b**, **213a**, **213b** of each edge director **111** includes a glass wettability with a static contact angle of less than about 60°, such as within a range of from about 30° to about 60°, such as from about 30° to about 50°, such as from about 30° to about 40°, such as from about 30° to about 35°.

In some examples, at least the outer portion **301**, **401** of each edge director **111**, such as the entire edge director, can comprise a platinum alloy. In one example, the platinum

alloy includes a metal selected from the group consisting of tin, copper and silver to respectively form a platinum-tin alloy, a platinum-copper alloy or a platinum-silver alloy. For instance, the platinum alloy can comprise a platinum-tin alloy including tin in an amount that is less than about 5 weight % tin (Sn). For example, the platinum-tin alloy can include from about 0.05 weight % tin (Sn) to about 3.5 weight % tin (Sn). In another example, the platinum-tin alloy can include from about 0.5 weight % tin (Sn) to about 2.5 weight % tin (Sn), such as from about 1 weight % tin (Sn) to about 2 weight % tin (Sn), such as about 1.25 weight % tin (Sn) to about 1.75 weight % tin (Sn), such as about 1.5 weight % tin (Sn).

The method can further include the step of flowing a molten glass sheet over each of the pair of inclined surface portions **107a**, **107b** of the forming wedge **105**. For example, as shown in FIG. 2, a central portion **215a** of a first molten glass sheet flows over the first inclined surface portion **107a** of the forming wedge **105**. Likewise, a central portion **215b** of a second molten glass sheet flows over the second inclined surface portion **107b** of the forming wedge **105**.

As shown in FIG. 2, the method can also include the step of flowing a first pair of lateral edges **217a**, **217b** of the molten glass sheets over corresponding first surfaces **211a**, **211b** of the first edge director **111** and flowing a second pair of lateral edges of the molten glass sheets over corresponding first surfaces **211a**, **211b** of the second edge director, wherein the thickness of each of the first and second pair of lateral edges is decreased. One of a second pair of lateral edges of the molten glass sheets is referenced as **125** in FIG. 1 wherein the other of the pair of lateral edges is hidden. As the first and second edge director can be identical, it will be appreciated that FIG. 2 also provides a representation of flowing of the second pair of lateral edges (see **125**) of the molten glass sheets over corresponding first surfaces **211a**, **211b** of the second edge director **111** to decrease the thickness of each of the second pair of lateral edges. As each of the first pair of surfaces **211a**, **211b** extend from a corresponding one of the pair of inclined surface portions **107a**, **107b**, the surface area of travel increases in the downward direction, thereby stretching out the edge portions of the corresponding glass sheet to decrease the thickness of each of the pair of lateral edges.

The method further includes the step of flowing the first pair of lateral edges **217a**, **217b** over corresponding second surfaces **213a**, **213b** of the first edge director **111** and flowing the second pair of lateral edges of the molten glass sheets over corresponding second surfaces of the second edge director, wherein the first and second pair of lateral edges each converge together toward the draw plane **205**.

The method further includes the step of drawing the first pair of lateral edges **217a**, **217b** off the first edge director **111** and drawing the second pair of lateral edges off the second edge director. The first pair of lateral edges **217a**, **217b** fuse together to form a first fused edge **127a** of the glass ribbon **103** and the second pair of lateral edges fuse together to form a second fused edge **127b** of the glass ribbon **103**.

The invention has been described with reference to the example embodiments described above. Modifications and alterations will occur to others upon a reading and understanding of this specification. Example embodiments incorporating one or more aspects of the invention are intended to include all such modifications and alterations insofar as they come within the scope of the appended claims.

What is claimed is:

1. An apparatus for downwardly drawing glass ribbon comprising:

a forming wedge including a pair of inclined surface portions extending between opposed ends of the forming wedge and converging along a downstream direction to form a root, wherein a draw plane extends through the root; and

an edge director positioned at each of the opposed ends, each edge director including an outer portion defining a first pair of surfaces and a second pair of surfaces, wherein the first pair of surfaces each extend from a corresponding one of the pair of inclined surface portions, the second pair of surfaces extend from the first pair of surfaces and converge toward the draw plane, wherein the outer portion comprises a platinum-tin alloy, and wherein the first and second pair of surfaces of each edge director includes a glass wettability with a static contact angle within a range of from about 30° to about 60° for an alkaline earth boro-aluminosilicate glass.

2. The apparatus of claim 1, wherein the range of the static contact angle is from about 30° to about 50°.

3. The apparatus of claim 2, wherein the range of the static contact angle is from about 30° to about 40°.

4. The apparatus of claim 2, wherein the range of the static contact angle is from about 30° to about 35°.

5. The apparatus of claim 1, wherein the platinum-tin alloy includes less than about 5 weight % tin.

6. The apparatus of claim 5, wherein the platinum-tin alloy includes from about 0.05 weight % tin to about 5 weight % tin.

7. The apparatus of claim 6, wherein the range of the static contact angle is from about 30° to about 50°.

8. The apparatus of claim 6, wherein the platinum-tin alloy includes from about 0.05 weight % tin to about 3.5 weight % tin.

9. The apparatus of claim 8, wherein the range of the static contact angle is from about 30° to about 50°.

10. The apparatus of claim 8, wherein the platinum-tin alloy includes from about 0.5 weight % tin to about 2.5 weight % tin.

11. The apparatus of claim 10, wherein the range of the static contact angle is from about 30° to about 50°.

12. An apparatus for downwardly drawing glass ribbon comprising:

a forming wedge including a pair of inclined surface portions extending between opposed ends of the forming wedge and converging along a downstream direction to form a root, wherein a draw plane extends through the root; and

an edge director positioned at each of the opposed ends, each edge director including an outer portion defining a first pair of surfaces and a second pair of surfaces, wherein the first pair of surfaces each extend from a corresponding one of the pair of inclined surface portions, the second pair of surfaces extend from the first pair of surfaces and converge toward the draw plane, wherein the outer portion comprises a platinum alloy including from about 0.05 weight % tin to about 5 weight % tin.

13. The apparatus of claim 12, wherein the platinum alloy includes from about 0.05 weight % tin to about 3.5 weight % tin.

14. The apparatus of claim 13, wherein the platinum alloy includes from about 0.5 weight % tin to about 2.5 weight % tin.

15. An apparatus for downwardly drawing glass ribbon comprising:

a forming wedge including a pair of inclined surface portions extending between opposed ends of the forming wedge and converging along a downstream direction to form a root, wherein a draw plane extends through the root; and 5

an edge director positioned at each of the opposed ends, each edge director including an outer portion defining a first pair of surfaces and a second pair of surfaces, wherein the first pair of surfaces each extend from a corresponding one of the pair of inclined surface portions, the second pair of surfaces extend from the first pair of surfaces and converge toward the draw plane, wherein the outer portion comprises a platinum alloy including a metal selected from the group consisting of tin, copper and silver, and wherein the first and second pair of surfaces of each edge director includes a glass wettability with a static contact angle within a range of from about 30° to about 60° for an alkaline earth boro-aluminosilicate glass. 10 15

16. The apparatus of claim **15**, wherein the range of the static contact angle is from about 30° to about 50°. 20

17. The apparatus of claim **16**, wherein the range of the static contact angle is from about 30° to about 40°.

18. The apparatus of claim **17**, wherein the range of the static contact angle is from about 30° to about 35°. 25

19. The apparatus of claim **15**, wherein the platinum alloy includes tin.

* * * * *